
Space Weather Technical Forecast

Issued on Saturday 21 December 2024 at 12:02 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: R1/R2 Likely. High uncertainty geomagnetic forecast.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity measured at GOES16 has been Moderate, with the peak flare an M1.9 at 21/0039UTC from AR3932 in the southeastern quadrant.

There are up to ten sunspot regions, with a new unnumbered bipolar region now becoming visible in the northeastern quadrant. The main changes in the period were rapid emergence of AR3930 in the southwest quadrant, albeit from a low base complexity. To its east, AR3922 apparently showed fewer constituent spots, although this may be related to its position nearing the western limb. The southeastern quadrant harbours a trio of nominally complex regions, AR3927 showed the emergence of a central penumbral spot but was otherwise largely unchanged as a Fsi/Beta. AR3928 to its south showed proliferation of many small central spots to become a compact Zurich region. Finally, trends in AR3932 nearer the limb were more difficult to ascertain, however the trailing penumbral spots appeared to increase in size over the past day.

Confidence in the roster of Coronal Mass Ejections (CMEs) is currently low, with significant H-Alpha and coronagraph imagery gaps in the period, as well as the ongoing SDO outage.

At the time of writing, the most notable possible CME progenitors (nearest centre-disc) included a possible small filament eruption and minor dimming 20/2200UTC from S10E010. This activity was accompanied by a slow mid-ranking C4.9-class flare. Also of note was another filament eruption 21/0430UTC visible on SUVI 304 imagery from the southwest quadrant near S30W040. The northeastern quadrant also showed a potential two-stage filament lift-off from just east of the meridian at 20/1330UTC and completing at 20/2300UTC on Big Bear H-Alpha. Significantly, but likely further from the Sun-Earth line, a large filament lifted off the northwest disc 21/1100UTC, with imagery also pending.

Analysis of the above events is ongoing but there is very little triangulating STEREO A COR2 data for the period, and long gaps in Lasco.

Solar Wind / Geomagnetic Activity: Solar winds, observed at L1 by DSCOVR and ACE have shown Elevated conditions with uncertain cause - perhaps connection to an unseen westward promontory from CH01/- in the southwestern quadrant given the persistently negative (towards the Sun) phi angle. The solar wind speed increased overall from Slightly Elevated to Elevated levels from 425 to 525km/s. The solar wind density differed according to the measuring satellite, with

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

ACE and Background single figures ppcc perhaps preferred. The IMF was Slightly Elevated as high as 9nT, with an erratic north-south component ranging between +/-8nT.

The net result of the above solar wind measures was for provisionally Quiet to Active Kp, peaking at '4-' in the 03-06UTC interval.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) observed by GOES18 gradually increased in the period but remained sub-S1 (10pfu), reaching 2.1pfu at 21/1110UTC before apparently stabilising - it is not yet clear as to whether this is a temporary trend or not.

High energy electron flux (greater than 2MeV) observed by GOES16 peaked at Moderate levels, with 350pfu observed at 21/1135UTC. The associated 24-hour fluence was below the Active (1e8 integrated flux) threshold. The 21/0001UTC observation was 1.0e7 integrated pfu, with a level tendency.

Four-Day Space Weather Forecast Summary

Solar Activity: Isolated M-class flares are Likely, mainly from AR3928 or AR3932, perhaps bolstered slightly after the current UTC weekend by returning regions. A Slight Chance of isolated X-class flares is maintained throughout.

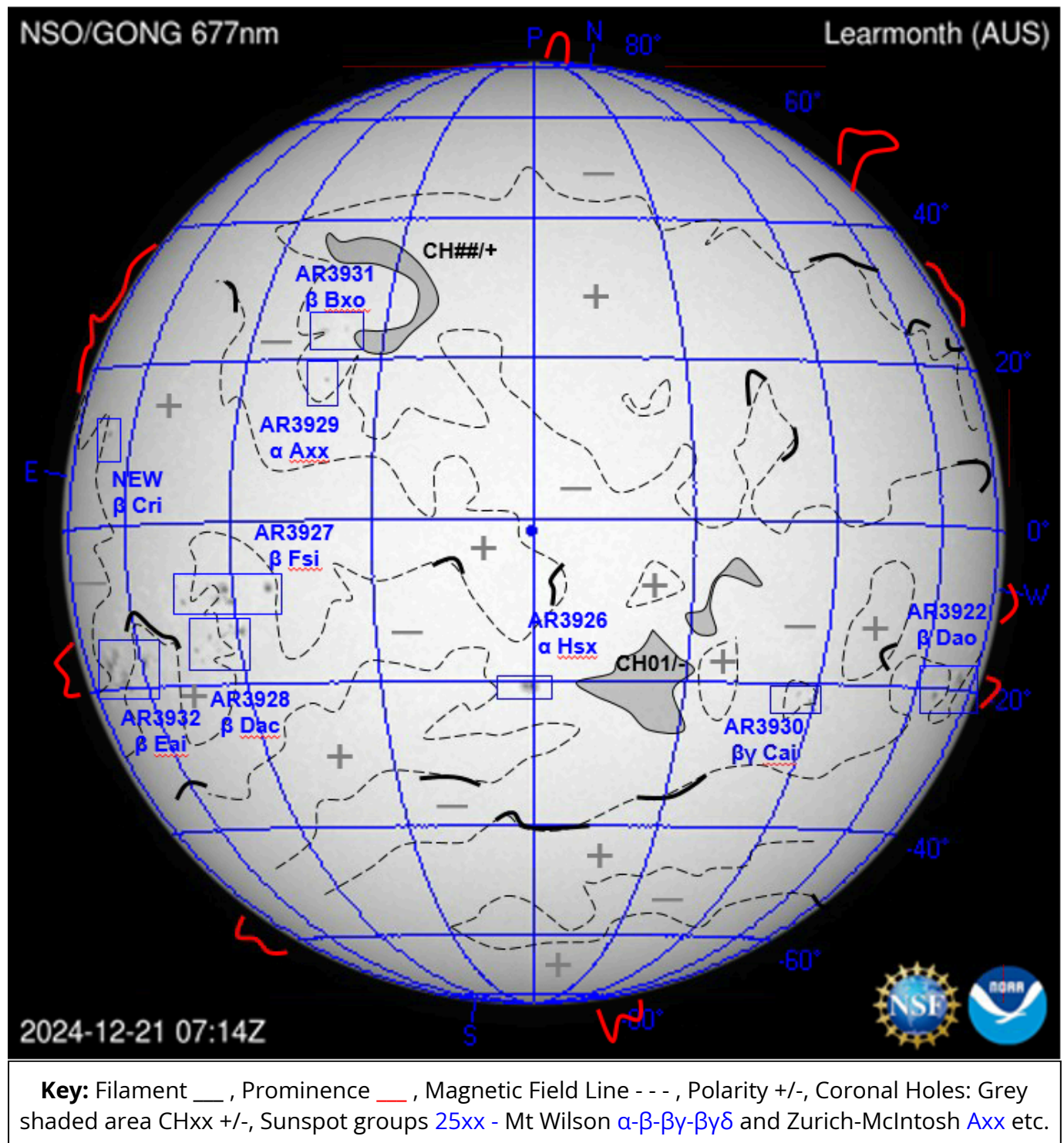
Solar Wind / Geomagnetic Activity: No Earth-directed CMEs currently feature in the forecast, although this aspect carries notably low confidence and there are as-yet unassessed CME candidates from the past 24 hours.

Current solar winds are Elevated via an uncertain mechanism, potentially early connection to CH01/-. CH01/- itself is a non-persistent feature, which also serves to lower forecast confidence. Overall, there is a Slight Chance of Minor Storm G1 conditions into the new UTC week as a result.

Energetic Particles / Solar Radiation: There is a Chance of S1-level enhancements in the current UTC weekend due to current slightly enhanced near-Earth proton counts. This risk should relax back to nearer the raw value for the disc in the absence of further suitable flares, with most of the risk from the front-side then tied to the westward advance of the complex southeastern trio sunspot regions.

The high energy electron forecast carries lower-than-average confidence due to inherited uncertainties from the geomagnetic forecast, especially surrounding any possible onset of CH01. Overall, the chances of disturbances in the period are higher than average, with perhaps a gradually rising Slight Chance perhaps the best representation.

Figure 1: Solar synoptic map, valid 21/0714UTC.



Geomagnetic Storms

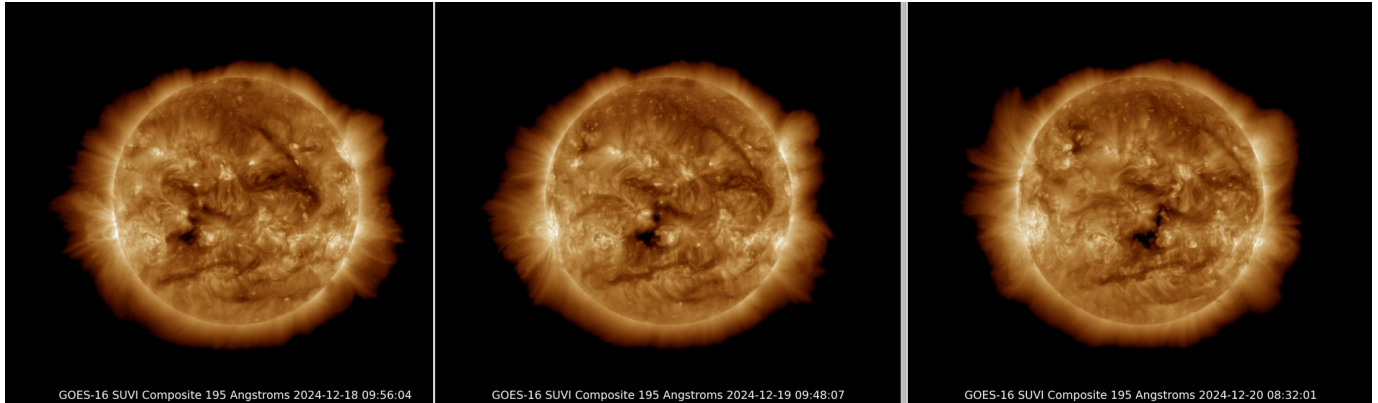
No Earth-directed CMEs currently feature in the forecast, although this aspect carries notably low confidence and there are as-yet unassessed CME candidates from the past 24 hours.

Current solar winds are Elevated via an uncertain mechanism, potentially early connection to CH01/- given the phi angle. The coronal hole itself has shown changes in shape over the past three or four days, making onset forecasting more complicated. Flux looping to its immediate west in GOES SUVI 195 imagery may be masking any leading portion of this hole, although the main feature still seems rather far east for current observations, and there may be an alternative cause. This is the main forecast feature due in the period, and the fact that it may already be in course lowers confidence for the forecast as a whole. CH01/- itself is a non-persistent feature, further exacerbating the issue.

Overall, and given now-Elevated solar wind speeds, there is a Slight Chance of Minor Storm G1 conditions through the period, tentatively reducing beyond the end of this four-day forecast with CH01/- likely to have eased. A mitigating factor against larger effects from any coronal hole is being near the semi-annual minimum coronal hole geoeffectivity near the solstice.

Geomagnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	5	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: GOES SUVI 195 imagery sequence showing centre-disc evolution of CH01/- through the period 18-20 December inclusive. There may be a westward promontory from this feature that could be the cause of current Elevated solar winds, although this is conjectural.



Radio Blackouts - X-Ray Flares

The chances of M- and X-class flares have been revised upwards relative to recent guidance, near the new raw value for the disc giving the emerging complexity of the southeastern quadrant - all while comparatively little sunspot complexity is being lost over the southwestern solar horizon. Added to this is the potential for some eastern limb arrivals over the current UTC weekend, perhaps foremost amongst these being Ex-AR3910, with Ex-AR3912 then also due Monday 23 December.

Overall, M-class flares are Likely throughout, with X-class rated a Slight Chance.

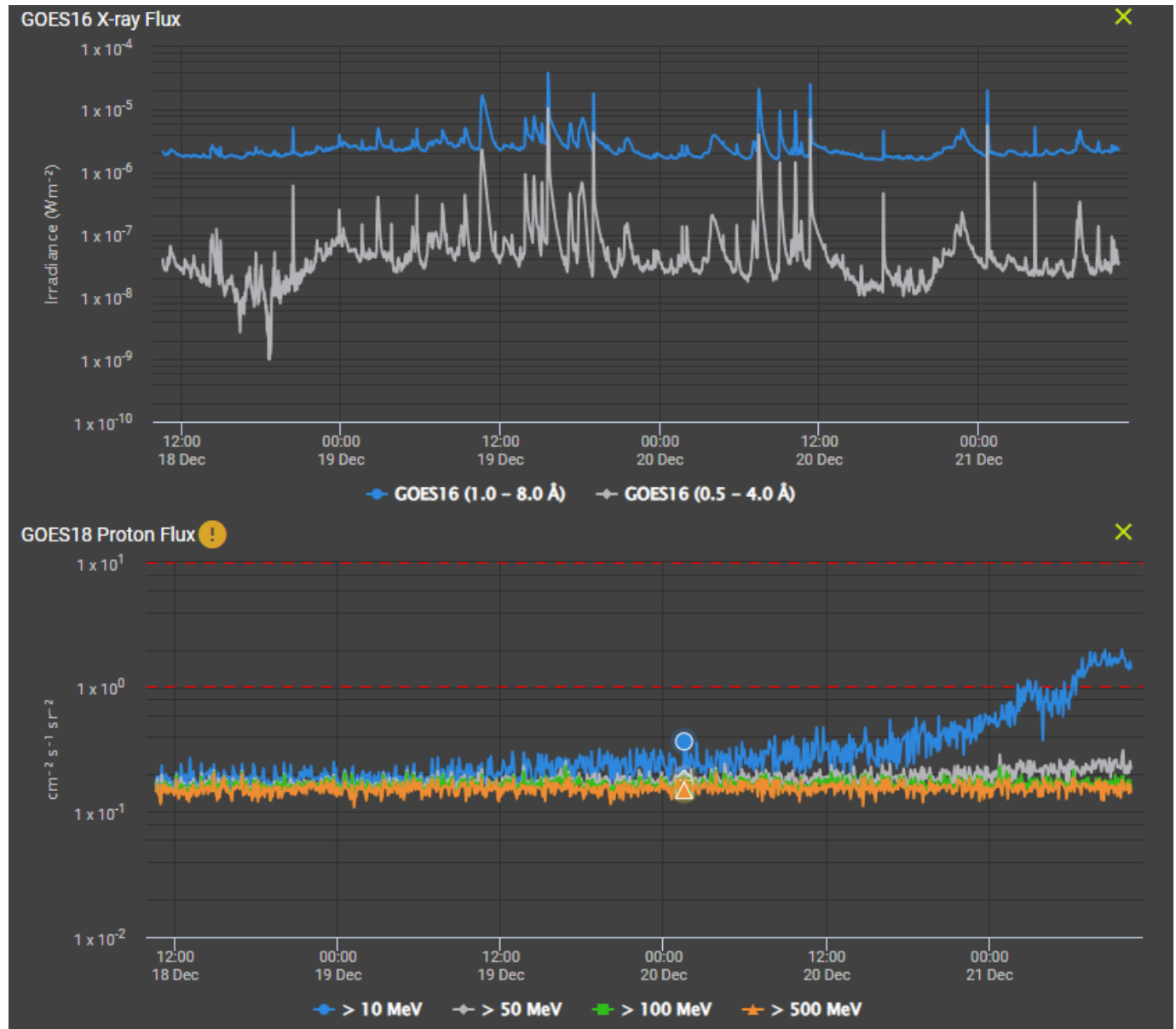
X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	70	70	75	75
Very Active	R3-R5 (X Class)	No	10	10	10	10

Solar Radiation Storms (High Energy Protons)

The source of the currently observed enhancement in the near-Earth environment is uncertain, but given the damped rise and soft spectrum, an eastern solar hemisphere or far-sided source seems most likely, perhaps from 19 December with possible further additions since. The chances of S1-scale events are currently slightly raised as a result of the increased counts, however barring further additions, a relaxing back towards the raw disc value of 15% is forecast. This should then resume the standard gradually increasing trend as the main southeastern sunspot regions advance westwards.

Radiation Storms	Level ($\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	25	20	15	20
Very Active	$\geq \text{S3}^*$	No	1	1	1	1
* $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and/or $50 \text{ MeV} \geq 10 \text{ pfu}$. ($\text{pfu} = \text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)						

Figure 3: GOES16 X-ray activity and GOES18 high energy proton flux response. Front-sided activity increased from 19 December, however the slow rise of proton flux at GOES18 could equally hint at far-sided activity. Current slightly enhanced proton counts make exceedence of S1 marginally more probable.



High Energy Electrons ($\geq 2\text{MeV}$)

The current high energy electron flux oscillation appears to have reached a steady state and is now very slightly eroding day-on-day. This trend may abruptly accelerate at GEO given recently observed Elevated solar winds and Active geomagnetic activity, with the period as a whole carrying low confidence as a result of an uncertain CME picture and non-recurrent - and in fact possibly already underway - coronal hole.

MOSWOC REFM does not represent either any impinging CME activity nor non-persistent coronal holes, and as such is not expected to provide useful guidance in the period.

All considered, there is a gradually rising Slight Chance of 24-hour fluence reaching Active.

GEO Electron Environment	Level ($\text{cm}^{-2}\text{sr}^{-1}\text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2\text{ MeV}$ $\geq 1\times 10^8$	No	5	5	5	10
Very Active	$\geq 2\text{ MeV}$ $\geq 1\times 10^9$	No	1	1	1	1

Figure 4: L1 solar wind speed, GOES16 electron flux and BGS geomagnetic indices since 18 December to current time, showing current diurnal oscillation reached in the wake of the 17 December CME. The diurnal flux oscillation may suffer short-notice drop-outs given the elevated solar wind environment at present, with the extent of later recovery also uncertain.

